

Effects of Energy Feed Combinations and Non-Protein Nitrogen on Feed Intake and Nutrient Digestibility in Saanen Crossbred Goats

Ho Xuan Nghiep^{1,2} and Nguyen Binh Truong^{1,2*}

¹Department of Animal and Veterinary Sciences, An Giang University, An Giang, Vietnam. No 18, Ung Van Khiem street, Dong Xuyen ward, Long Xuyen city, An Giang province; ²Vietnam National University Ho Chi Minh City, Vietnam

*Corresponding authors e-mail: nbtruong@agu.edu.vn

This study was carried out from February to May 2024 at the experimental farm of An Giang University, Vietnam National University Ho Chi Minh City, Vietnam. The experiment was conducted using a Latin square design on 4 male Saanen crossbred goat (25.2±1.06 kg). Treatments were maize and cassava chips (Ma.C); maize, cassava chips and urea (Ma.C.U); broken rice and cassava chips (BrR.C); broken rice, cassava chips and urea (BrR.C.U) in basal diet of premix, tofu waste, *Operculina turpethum* vines and fresh elephant grass *ad libitum*. than without. It was 7.68, 7.88, 8.43 and 8.80 MJ/goat/day corresponding to Ma.C, Ma.C.U, BrR.C and BrR.C.U treatments. The result showed that dry matter intake per body weight (%) tended to increase ($P>0.05$) from Ma.C treatment to Ma.C.U, BrR.C and BrR.C.U treatments (2.67, 2.68, 2.79 and 2.85%, respectively). The ME consumption was higher ($P>0.05$) with urea BrR.C.U treatments. The dry matter digestibility (%) of BrR.C.U was higher ($P<0.05$) than Ma.C. treatment but it was not different ($P>0.05$) with BrR.C and Ma.C.U treatments (76.9, 71.1, 72.3 and 72.6%, respectively). The crude protein digestibility tended to be higher ($P>0.05$) with urea than without. In detail, It was 81.6, 78.2, 69.8 and 68.8% corresponding to Ma.C.U, BrR.C.U, Ma.C and BrR.C.U treatments. The nitrogen retention was lower ($P>0.05$) for the Ma.C treatment and higher in the BrR.C.U treatment (5.69 and 10.3 g/goat/day, respectively). The Ma.C and BrR.C treatments were not different ($P>0.05$) for nitrogen retention. Similarly, Ma.C.U and BrR.C.U were not different ($P>0.05$) for nitrogen retention. The daily weight gain was higher ($P>0.05$) with urea than without. In conclusion, the energy feed combination and without urea or urea that feed intake, nutrient value and nitrogen retention well from high to low were BrR.C.U, Ma.C.U, BrR.C and Ma.C treatments.

Keywords: Combinations, energy feed, non-protein nitrogen, small ruminant, goat nutrition, rumen, age period, crude protein

INTRODUCTION

The goat is one of the ruminant species selected to keep in priority with browsing behaviors adapting to feeds from plants and advantage characteristics of drought stand. In Vietnam, demand for goat meat has increased significantly in the past decades (Gray and Walkden-Brown, 2019). According to Don *et al.* (2023), Vietnam's goat population is thought to have grown by more than twice as much in the past ten years. Agricultural by-products and local feeds are very popular in the Mekong Delta from the countryside to market such as broken rice and *Operculina turpethum* vines. Goat breeding in tropical condition commonly is based in poor energy and protein content forages (Shinde and Mahanta, 2020; Nair *et al.*, 2021). Preston *et al.* (2021) state that ruminant feeding systems in the tropics should be based on trees and shrubs supplemented with carbohydrate-rich

byproducts of agro-industrial crops in order to address the emergencies of climate change and biodiversity loss. According to Tripathi *et al.* (2006), the quality and quantity of feed are the main barriers to raising ruminant productivity in tropical environments. In a prior study, Truong *et al.* (2024) discovered that broken rice & wheat, broken rice & cassava chip, maize & cassava chip, and maize & wheat were the energy feed combinations that well fed intake, nutrient value, nitrogen retention, and daily weight increase on Saanen crossbred goats. Saanen crossbreeds can utilize energy and protein sources of feeds more than local goats, as a crossbreeding achievement. Utilizing starch content from agricultural by-products is seen as a promising approach for ruminant feeding (Dung, 2014).

According to Ngu *et al.* (2019), the supply of protein sources to the ruminant diet plays an important role in rumen fermentation and protein synthesis of microorganisms,

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resulting in productivity gains of ruminants. Urea (non-protein nitrogen, NPN) is a macronutrient for the growth of microorganisms reported by [Suryani et al. \(2017\)](#). [Wahyono et al. \(2022\)](#) concluded that urea supplementation to animals may stimulate nutrient digestibility and improve performance and carcass yield. In addition, [Khattab et al. \(2013\)](#) proposed that using NPN sources, like urea, in meals high in soluble carbohydrates could be helpful in lowering diet expenses. [Paengkoum et al. \(2006\)](#) reported that supplementation of energy enhanced utilization of urea and resulted in higher animal performance as a consequence of improved ruminant fermentation, microbial yield and nitrogen balance. However, developing and exploiting of local feed resources in the Mekong Delta is a good strategy to provide feeds for ruminants. Furthermore, livestock-related economics depend on farmers using feed to generate large financial profits. As a result, it is important to examine the pairing of protein and energy feed sources for goats. This is a management key factor in feed formulation for goats as stated in [Simões et al. \(2021\)](#).

Thus, this study postulates that energy feed combinations and nitrogen that isn't protein may have an impact on goats' feed intake, nutritional digestibility, and nitrogen retention.

MATERIALS AND METHODS

From February to May 2024, the experiment was conducted at An Giang University's experimental farm, which is part of the department of animal and veterinary science. At laboratory E205 (Ruminal animal production techniques – 4) of the Faculty of Animal Sciences, Agriculture University of Can Tho University, the chemical makeup of the experimental diets was examined.

Table 1. Ingredients composition used in the experiment.

| Ingredients (%DM) | Ma.C | Ma.C.U | BrR.C | BrR.C.U |
|-----------------------------------|------|--------|-------|---------|
| Maize | 15.0 | 15.0 | - | - |
| Broken rice | - | - | 15.0 | 15.0 |
| Cassava chips | 15.0 | 15.0 | 15.0 | 15.0 |
| Tofu waste | 5.00 | 5.00 | 5.00 | 5.00 |
| <i>Operculina turpethum</i> vines | 30.0 | 30.0 | 30.0 | 30.0 |
| Elephant grass | 34.3 | 33.3 | 34.3 | 33.3 |
| Urea | - | 1.00 | - | 1.00 |
| Premix | 0.70 | 0.70 | 0.70 | 0.70 |
| Total | 100 | 100 | 100 | 100 |

Materials: Four male Saanen crossbreed goats (25.2±1.06 kg) were applied using Latin Square design (4x4) with the period of 2 weeks for adaptation and 1 week for data collection. The four treatments were energy feed combinations such as maize and cassava chips (Ma.C); broken rice and cassava chips (BrR.C); maize, cassava chips and urea (Ma.C.U); broken rice, cassava chips and ure (BrR.C.U). The Saanen crossbreed

goats, energy feeds and compositions of diets are shown in Tables 1 and Figure 1, 2, 3 & 4.

Table 2. Chemical composition of experimental feeds (DM%).

| Feed | DM % | DM % | | | |
|-----------------------------------|------|------|------|------|------|
| | | OM | CP | NDF | ADF |
| Maize | 85.6 | 96.3 | 8.50 | 23.7 | 4.31 |
| Broken rice | 85.2 | 99.4 | 7.28 | 10.2 | 3.16 |
| Cassava chips | 85.8 | 95.7 | 3.50 | 13.8 | 4.77 |
| Tofu waste | 18.9 | 97.1 | 18.8 | 35.1 | 23.9 |
| <i>Operculina turpethum</i> vines | 12.6 | 88.0 | 13.5 | 40.7 | 31.9 |
| Elephant grass | 14.8 | 92.0 | 9.20 | 64.8 | 41.9 |
| Urea | 99.6 | - | 286 | - | - |

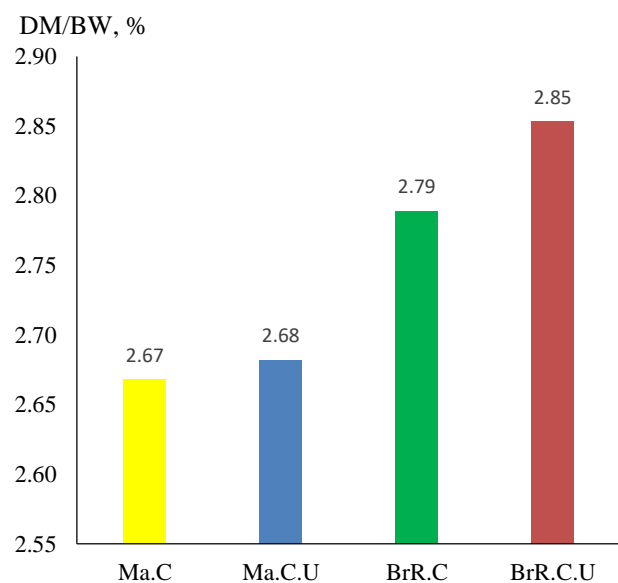


Figure 5. DM intake per body weight is increased with a trend as the level of urea was increased in diets.

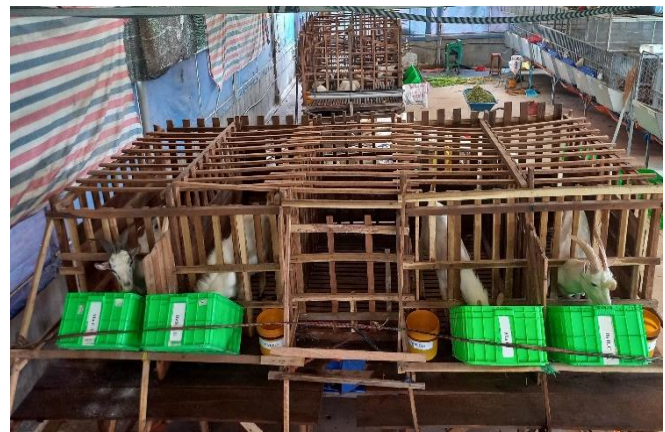


Figure 1. Individual pen of goats in this study.



Table 3. Impact of energy feed combinations and non-protein nitrogen on nutritional intakes and feed in this investigation.

| Item | Treatments | | | | SEM | P |
|--------------------------------------|-------------------|--------------------|--------------------|-------------------|-------|-------|
| | Ma.C | Ma.C.U | BrR.C | BrR.C.U | | |
| Feed intake, gDM/animal/day | | | | | | |
| Maize | 112 | 113 | - | - | - | - |
| Broken rice | - | - | 122 | 115 | - | - |
| Cassava chips | 110 | 110 | 122 | 115 | 5.420 | 0.410 |
| Tofu waste | 36.7 | 37.0 | 40.9 | 38.4 | 1.830 | 0.419 |
| <i>Operculina turpethum</i> vines | 269 | 272 | 306 | 286 | 13.70 | 0.314 |
| Elephant grass | 227 | 233 | 215 | 247 | 16.90 | 0.628 |
| Urea | - | 6.95 | - | 7.34 | - | - |
| Premix | 5.21 | 5.25 | 5.81 | 5.49 | 0.258 | 0.410 |
| Total nutrient intake, kg/animal/day | | | | | | |
| DM | 759 | 777 | 812 | 815 | 29.30 | 0.514 |
| OM | 693 | 702 | 745 | 740 | 26.30 | 0.460 |
| CP | 77.5 ^b | 98.9 ^{ab} | 83.4 ^{ab} | 104 ^a | 5.100 | 0.030 |
| NDF | 305 | 314 | 304 | 318 | 13.40 | 0.849 |
| ADF | 197 | 198 | 200 | 207 | 8.800 | 0.830 |
| CP/DM, % | 10.2 ^b | 12.7 ^a | 10.3 ^b | 12.8 ^a | 0.229 | 0.001 |
| DM/BW, % | 2.67 | 2.68 | 2.79 | 2.85 | 0.118 | 0.659 |
| ME, MJ/day | 7.68 | 7.88 | 8.43 | 8.80 | 0.337 | 0.177 |

**Figure 2. Maize****Figure 4. Cassava chips****Figure 3. Broken rice**

Material preparation: Prior to feeding, each meal was weighed and given to the experimental goats in different portions. Depending on each treatment, the mix consisted of two feedings at 7:00 am and 1:00 pm, and it contained maize, broken rice, cassava chips, urea, and premix. At 1:30 pm, the tofu waste was fed. Two feedings were given to the *Operculina turpethum* vines at 8:00 am and 2:00 pm. Freshwater and elephant grass were available at all times. Every morning, freshwater and rejected feeds were weighed.

Feed, nutrient, and energy intakes: Refusals were gathered and weighed every morning, and daily intakes of feed and nutrients were computed from feed. The dry matter (DM) and organic matter (OM) contents of feeds provided, refusals, and feces were tested in accordance with [AOAC \(1990\)](#) protocols;



Table 4. Apparent nutrient digestibility of goats.

| Item | Treatments | | | | SEM | P |
|----------------------------------|-------------------|--------------------|--------------------|-------------------|-------|-------|
| | Ma.C | Ma.C.U | BrR.C | BrR.C.U | | |
| Feces, gDM/goat/day | 221 | 216 | 222 | 187 | 9.64 | 0.120 |
| Nutrient digestibility, % | | | | | | |
| DM | 71.1 ^b | 72.6 ^{ab} | 72.3 ^{ab} | 76.9 ^a | 1.14 | 0.047 |
| OM | 73.6 ^b | 74.7 ^{ab} | 74.5 ^{ab} | 78.5 ^a | 0.99 | 0.048 |
| CP | 69.8 | 81.6 | 68.8 | 78.2 | 3.02 | 0.060 |
| NDF | 62.9 | 63.0 | 58.8 | 69.8 | 2.55 | 0.105 |
| ADF | 58.6 | 59.6 | 57.7 | 64.3 | 1.65 | 0.105 |
| Digestive nutrient, g/animal/day | | | | | | |
| DM | 539.0 | 561.0 | 590.0 | 628.0 | 25.60 | 0.179 |
| OM | 509.0 | 522.0 | 558.0 | 583.0 | 22.30 | 0.177 |
| CP | 53.9 ^b | 80.5 ^a | 58.1 ^b | 80.6 ^a | 2.82 | 0.001 |
| NDF | 194.0 | 197.0 | 183.0 | 224.0 | 13.50 | 0.262 |
| ADF | 114.0 | 119.0 | 115.0 | 136.0 | 8.05 | 0.274 |

the nitrogen (N) content of the feeds, refusals, feces, and urine was analyzed using the Kjeldahl methods (AOAC, 1990). Van Soest *et al.* (1991) method was used to analyze acid detergent fiber (ADF) and neutral detergent fiber (NDF). According to Bruinenberg *et al.* (2002), the metabolizable energy (ME) of the diets was determined as follows: ME (MJ/animal/day) = $14.2 \times \text{DOM} + 5.9 \times \text{DCP}$ (with DOM/DCP < 7.0) or ME (MJ/animal/day) = $15.1 \times \text{DOM}$ (with DOM/DCP > 7.0). Whereas digestible crude protein is DCP and digestible organic matter is DOM.

Apparent nutrient digestibility: McDonald *et al.* (2010) applied apparent digestibility coefficients for nitrogen retention, DM, OM, CP, NDF, and ADF. Every three-week trial period consisted of two weeks for adaptation and one week for collecting urine and feces.

Nitrogen retention: Daily N retention was calculated by daily collected N intake, N feces and N urine as following formula: N retention = N intake - (N feces + N urine).

Daily weight gains (DWG): The Saanen crossbred goats were weighed in the morning prior to feeding, at the beginning and end of each experimental period means two consecutive days.

Statistical analysis: The Minitab Reference Manual Release 20.3's ANOVA Linear Model (GLM) was used to analyze the data (Minitab, 2021). When there was a significant overall effect, Tukey's test ($P < 0.05$) was also used to analyze differences among means. $y_{ijk} = \mu + T_i + A_j + P_k + e_{ijk}$ was the statistical equation for this model, where y_{ijk} is the dependent variable, μ is the overall mean, T_i is the treatment effect ($i = 1$ to 4), A_j is the goat effect ($j = 1$ to 4), P_k is the period effect ($k = 1$ to 4), and e_{ijk} is the random error.

RESULTS AND DISCUSSION

Chemical composition and ingredients of experimental feeds

ME intakes, feed and, nutrient of experimental goats (Table 3)

The experimental goat's apparent nutritional digestibility and digestive nutrient (Table 4)

Nitrogen retention values and daily weight gain of goats (Table 5)

Table 5. Nitrogen retention and daily weight gain of goats.

| Item | Treatments | | | | SEM | P |
|--------------------------------|--------------------|---------------------|---------------------|--------------------|-------|-------|
| | Ma.C | Ma.C.U | BrR.C | BrR.C.U | | |
| Urine, g/goat/day | 2,421 | 2,114 | 1,921 | 2,118 | 143.0 | 0.203 |
| Nitrogen (N), g/head/day | | | | | | |
| N intake | 12.40 ^b | 15.80 ^{ab} | 13.30 ^{ab} | 16.60 ^a | 0.816 | 0.030 |
| N fecal | 3.78 | 2.95 | 4.05 | 3.75 | 0.619 | 0.645 |
| N urin | 2.94 | 3.09 | 2.37 | 2.61 | 0.410 | 0.623 |
| N retention | 5.69 ^c | 9.78 ^{ab} | 6.93 ^{bc} | 10.30 ^a | 0.595 | 0.004 |
| N retention/BW ^{0.75} | 0.46 ^c | 0.79 ^{ab} | 0.55 ^{bc} | 0.83 ^a | 0.051 | 0.006 |
| Body weight, kg/goat | | | | | | |
| BW Initial | 27.60 | 28.00 | 28.20 | 27.70 | 0.355 | 0.658 |
| BW Final | 29.00 | 29.60 | 29.60 | 29.30 | 0.299 | 0.528 |
| Daily weigh gain, g | 66.70 | 73.10 | 66.80 | 77.00 | 12.10 | 0.909 |



DISCUSSION

The results of Table 2 showed that the CP content was higher in maize (8.50%) than broken rice (7.28%) and cassava chips (3.50%) in group energy feed. In forage, the *Operculina turpethum* vines (40.7%) was lower NDF content than elephant grass (64.8%). The chemicals of feeds in experimental goat agree with the result of some previous studies. The composition chemical of the maize, [Dung \(2014\)](#) reported 10.5% CP and 20.3% NDF. The nutrient of *Operculina turpethum* vines was 15.6% CP, 40.9% NDF and 11.2% ADF shown by [Trung and Thu \(2018\)](#). [Rusdy \(2016\)](#) found that elephant grass's CP, NDF, and ADF were about 7.20–12.1%, 57.4–75.4% and 30.6–51.7%. Thus, the feed nutrient in the present study agrees and has small changes with previous studies. That is influenced by the harvest season and soil of the research are.

The DM intake (g/goat/day) did not change substantially ($P>0.05$) among treatments, according to Table 3's results. In accordance with the Ma.C, Ma.C.U, BrR.C, and BrR.C.U treatments, it was 759, 777, 812, and 815 g. On the other hand, DM intake was higher ($P>0.05$) in the BrR.C and BrR.C.U treatments compared to the Ma.C and Ma.C.U treatments. To be more specific, the DM/BW (%) went up from 2.67, 2.68, 2.79, and 2.85% for Ma.C to Ma.C.U, BrR.C, and BrR.C.U treatments. Figure 5). The proportion of DM/BW (%) in goats was 2.72–3.01 percent in this investigation, which was comparable to the results published by [Hong et al. \(2021\)](#). The CP intake (g/goat/day) varied substantially ($P<0.05$) between treatments, with the Ma.C treatment having the lowest CP intake (77.5 g) and the BrR.C.U treatment having the greatest (104 g). In contrast, there was no difference ($P>0.05$) between the BrR.C (83.4 g) and BrR.C.U therapies and the Ma.C.U therapy (98.9 g). Given that the addition of urea increased the amount of $\text{NH}_3\text{-N}$, the study results of [Pongsub et al. \(2024\)](#) demonstrate that the quick breakdown of urea into ruminal $\text{NH}_3\text{-N}$ by bacterial enzymes is acceptable. [Dong and Thu \(2020\)](#) claim that the body needs protein for both cell repair and synthesis processes. One crucial aspect of nutrition and metabolism is the conversion of feed protein into body protein. Increases in urea supplementation in diets led to a rise in ME intake ($P>0.05$). For Ma.C, Ma.C.U, BrR.C, and BrR.C.U treatments, it was 7.68, 7.88, 8.43, and 8.80 MJ/goat/day. It was clarified by [Khatab et al. \(2013\)](#) that fermentable carbohydrates and rumen-solubilized protein and/or N are the two main dietary components needed by ruminal bacteria for growth. The increased nitrogen content of urea supplements in meals served as evidence. In this study, we found that CP intake was affected by supplementation with urea. However, nutrient intake was lower in maize combined with cassava than in broken rice and cassava together.

Table 4 demonstrated that while the dry matter digestibility of the BrR.C.U treatment (76.7%) was not substantially different

($P>0.05$) from that of the Ma.C.U treatment (72.6%) or the BrR.C.U treatment (72.6%), it was higher ($P<0.05$) than the Ma.C. treatment (71.1%). This study's results on DM digestibility were comparable to those of [Truong et al. \(2024\)](#), who discovered that DM digestibility was 15% and 15% depending on the combination (% dry matter intake) of two energy feed sources, such as corn and cassava chips with urea (70.5%) and broken rice and cassava chips with urea in the diets (75.1%). According to [Khatab et al. \(2013\)](#), when urea levels in the diet increased, there was a linear rise in the digestion of DM, OM, CP, and non-fibre carbs. The CP digestibility in our study was 69.8, 81.6, 68.8, and 78.2% (Ma.C, Ma.C.U, BrR.C, and BrR.C.U treatments, respectively), with no significant difference seen ($P=0.060$) amongst treatments. On the other hand, urea supplementation in diets had an impact on Ma.C.U and BrR.C.U, which had higher CP digestibility than Ma.C and BrR.C treatments. According to [Sari et al. \(2018\)](#), the higher digestibility of CP refers to the overall amount of CP material that can be broken down in the digestive tract. Furthermore, proteins—which are necessary for microbial activity—consist of urea, a common nitrogen nutrient ([Pongsub et al., 2024](#)). An increase in urea supplementation in meals led to a significant ($P<0.05$) increase in NDF digestibility. The comparable percentages for Ma.C, Ma.C.U, BrR.C, and BrR.C.U treatments were 62.9, 63.0, 58.8, and 69.8%. It was demonstrated that the NDF digestibility of cassava chips and broken rice mixed with urea was higher than that of maize and cassava chips mixed with urea. Nitrogen-supplemented diet, according to [Lopes et al. \(2021\)](#), accelerates the proliferation of fibrinolytic bacteria and improves fiber decomposition because of increased herbage digestibility. The energy feed used in this trial, which included cassava chips, broken rice, and maize, had less crude protein and less fiber than urea. The utilization of local feed and energy feed combinations containing urea demonstrated good nutritional digestibility and digestive nutrients. As a result, urea in combination with cassava chips and broken grains increased nutrient intake, digestibility, and digestive nutrients.

The findings shown in Table 5 showed that urea supplements increased the amount of nitrogen consumed (g/goat/day). It was 12.4, 15.8, 13.3, and 16.6 g/goat/day in accordance with the treatments for Ma.C, Ma.C.U, BrR.C, and BrR.C.U. As a precursor to microbial protein synthesis, this could lead to a higher incorporation of $\text{NH}_3\text{-N}$ and fermentable energy into microbial nitrogen ([Pongsub et al., 2024](#)). The nitrogen retention (g/goat/day) varied substantially ($P<0.05$) between treatments, with the Ma.C treatment having the lowest value (5.69 g) and the BrR.C.U treatment having the highest value (10.3 g). In contrast, there was no difference ($P>0.05$) between the BrR.C (6.93 g) and BrR.C.U treatments and the Ma.C.U treatment (9.78 g). [Paengkoum et al. \(2006\)](#) reported that the administration of urea or other non-protein nitrogen supplements stimulated feed intake, rumen digestibility, N



balance, and microbial development. The daily weight gain in this study was 66.7, 66.8, 73.1, and 77.0 g/head/day for the Ma.C, BrR.C, Ma.C.U, and BrR.C.U treatments, respectively, and showed a tendency of increase ($P>0.05$). The experiment's average weight increase (g/head/day) was 52.0–123g, which is comparable to research by [Trung and Thu \(2018\)](#). To put it briefly, a feed with a low NDF has a high content of non-structural carbohydrates. When coupled with urea, broken rice provided a more effective energy diet than maize. As a result, this study showed an increasing tendency in both daily weight gain and nitrogen retention.

Conclusion: the energy feed combination and urea affect feed intake, nutrient value, and nitrogen retention in Saanen crossbred goats. The present study's results recommend using local feed as an appropriate strategy for goat production.

Authors contributions statement: Truong N.B designed the experiments; Truong N.B and Nghiep H.X conceived performed the experiments; Truong N.B analyzed the data; Truong N.B and Nghiep H.X wrote the paper; all authors reviewed and approved the final manuscript.

Conflict of interest: Authors declared no conflict of interest.

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Ethical statement: Goats are used only for research purposes, and are loved and cared for with care.

Availability of data and material: We declare that the submitted manuscript is our work, which has not been published before and is not currently being considered for publication elsewhere?

Informed consent: N/A.

Consent to participate: All authors participated in this research study.

Consent for publication: All authors submitted consent to publish this research article in JGIAS

SDG's addressed: Zero Hunger, Good Health and Well-being.

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